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Infrared Sensor Kit as a Speed Detector in the Practicum of Energy and Momentum Laws

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Abstract

Material law of conservation of energy and momentum is abstract material. Practical tools are needed in learning to prove the law so that it can foster real learning for students. This research method is an experimental method that aims to find out how to test the energy conservation and momentum law practicum kit. The practicum kit consists of wheeled objects as loads, precision rails as slippery trajectories, and infrared sensor devices to detect the speed of motion of objects. The kits that have been compiled are then validated by experts before use. Kit validation results are valid. In the implementation of the kit testing the independent variables selected are object mass and slope height. The test results obtained that the kit equipped with infrared sensors is quite accurate in explaining the law of conservation of energy which is evidenced by the relative error that occurs is quite small, namely 1%. In testing the law of conservation of momentum obtained the result that the momentum value of the two objects before the collision approaches the momentum value after the collision. The kit testing results become a solution and innovation as a practical tool to help with more tangible learning.

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INTRODUCTION

The modern state of classical mechanics and classical physics makes it possible to express assumptions about the laws that govern phenomena in a concrete manner (Kanarev, 2002). The law of conservation of energy and momentum becomes a subject in physics. An object at a certain height has potential energy. When an object moves at zero initial velocity, the energy of the object is eternal. Objects that have eternal energy means having the same total mechanical energy in each position as they move. The law of conservation of this energy is the sum of potential energy and kinetic energy of objects at each point. Other mechanical properties experienced by moving objects are the law of conservation of momentum. Two moving objects with initial velocities that experience central collisions will produce the final velocity with the same total momentum as the result of mass times and velocities. Both act as if the mass of objects is concentrated at the center (Brunt & Brunt, 2013).

The energy conservation law and momentum conservation law are abstract concepts. Eternity law is associated with order (Lange, 2007). Both of these quantities become concrete concepts when they are proven in practicum (Barata, 2016). This proof causes problems for students when calculating the distance traveled by objects in a short time interval to obtain valid results. This learning problem needs learning solutions that must also be interesting. Nafisah et al. (2018) stated that the use of teaching aids can improve students' conceptual understanding. The 21st century national education paradigm also requires a role for teachers to become facilitators, so that innovative and communicative learning is needed that involves students in the learning process (Oktaviani et al., 2015). High student learning behavior can be compared with other friends in a group. This existence is able to influence the learning behavior of his friends well (Herlianti et al., 2015).

Some experiments have been developed. Razzaq & Leonardo (2013) conducted experiments with electric toy cars moving along long rotating stems. This experiment aims to help students understand the principles of conservation of angular momentum. Another study was carried out by Mughny and Endah (2016) by designing a trial kit to prove the momentum of microcontroller-based conservation law. The tool is able to prove the law of conservation of momentum in collisions is not at all dangerous. The law of conservation of energy and momentum can be proven by the infrared sensor circuit of the speed of motion of objects passing through it. The use of infrared sensors can be used as a new alternative as a measuring instrument with good sensitivity (Marinho & Paulucci, 2016). The infrared sensor is able to detect the speed of an object just before it reaches the base surface and the speed of the two objects shortly after the collision occurs. Duong & Choi (2013) in his research developed a new technique for using multiple infrared devices to process data.

The problem is the background of experimental research to prove the legal phenomenon of conservation of energy and momentum experienced by straight-moving objects. A practicum kit is prepared to prove the law of conservation of energy and momentum in its suitability with the theory.

METHODS

The method used in this study is experiment. The development of a practicum kit uses loads as objects, trajectories as objects moving, and equipped with an infrared sensor device to detect the velocity of objects. The kit kit has been validated by an expert team with valid results. The arrangement of the kit is shown in Figure 1. The infrared sensor being an important equipment in this experiment is shown in Figure 2. Initially the object is at a certain height in the inclined plane. The object is removed without the initial speed pounding the second object that is on a flat track. The infrared sensor is installed just at the end of the tilt plane and the second sensor is placed in front of the second object that is pounded. Speed data recorded by the infrared sensor is displayed on the LCD screen.

Figure 1. Experiment equipment series

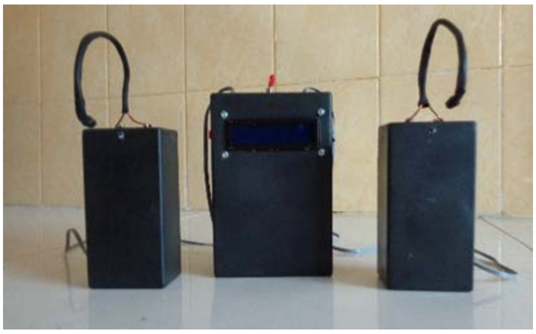

Figure 2. Infrared sensors

The independent variable in this study is the load mass and the slope height. This experiment can be done easily in the classroom by students without special assistance.

Proof of the law of conservation of energy is obtained by placing the beam on a sloping track with a certain slope height. The location of the beam height can be used in determining the amount of potential energy possessed by the load beam:

$$E_p = mgh$$

Where m is the mass of the load beam (kg), g is the magnitude of the earth's gravitational acceleration, h is the location of the height of the load beam (m). On the other hand, the speed of the load beam detected just before the base trajectory can be used to determine the amount of kinetic energy possessed by the load beam:

$$E_k = \frac{1}{2}mv^2$$

Where m is the mass of the load beam, v is the speed of the load beam just before touching the base of the track.

Based on the theory of mechanics, every object that moves fulfills the law of conservation of energy, where the total mechanical energy of an object is always the same at every point passed by an object. The total mechanical energy of an object is affected by the amount of potential energy and kinetic energy of the object.

$$E_m = E_p + E_k$$

$$mgh_1 + \frac{1}{2}mv_1^2 = mgh_2 + \frac{1}{2}mv_2^2$$

The movement of the load beam from a certain height until just before touching the base of the trajectory is a motion system that meets the law of conservation of energy, so that with the same mass of load beams, the speed right before touching the bottom of the trajectory can be expressed in the equation (Mughny & Endah, 2016)

$$v = \sqrt{2gh}$$

RESULTS AND DISCUSSION

Energy Conservation Law

The practice results show that the infrared sensor is able to detect the speed of moving objects along the path as shown in Figure 3. The results of the experiment to prove the law of energy conservation are shown in Table 1.

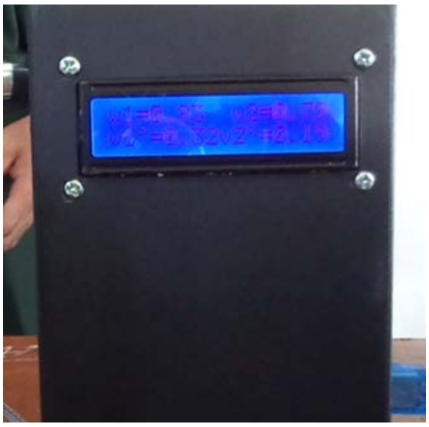

Figure 3. Display Screen on Sensor

Table 1. Mechanical Energy Data with a Second Mass of Fixed Objects (0.092 kg)

h(m)	E_m(J) above	v(m/s)	E_m(J) under
0.03	0.027048	0.766	0.026991
0.04	0.036064	0.885	0.036028
0.05	0.04508	0.989	0.044994
0.06	0.054096	1.084	0.054053
0.07	0.063112	1.171	0.063077
0.08	0.072128	1.252	0.072105

The data above shows the results of the calculation of mechanical energy in two positions. In the above position, mechanical energy is produced by the potential energy of the object because objects slide without initial speed. In the position below, the height of the object is at its lowest point so that the value of the potential energy is equal to zero and only has kinetic energy values. The amount of kinetic energy in the lower position is obtained from the infrared sensor which provides the velocity data of the object. From the second value the mechanical energy is obtained by a small difference between the upper position and the lower position.

Previous research conducted by Khumaeni et al. (2008) has proven the law of energy conservation using fine round plastic beads replacing metal ball bearings. To examine the law of energy conservation, the angle friction slope of (θ = 50°) consists of thin plastic sheets coated by fine plastic beads with an electrostatic force employed. Using this method, quantitative measurements of energy conservation law have been successfully carried out with less than 3% minor errors. As for the new kit test, the error value is 1%. A very small relative error value becomes the excess of the kit. Kit design and testing is very helpful for teachers and students to be able to learn more concretely. Usrotin et al. (2013) revealed that in practicum activities, students can develop problem solving skills through scientific methods by understanding problems, formulating hypotheses, collecting evidence or data, reaching conclusions until finding concepts. Harjono et al. (2013) in his research stated that cooperative learning can improve students' performance. Through this learning makes what is learned has the benefits for themselves, others, and the community (Azimi et al., 2017).

Momentum Conservation Law

Proof of the law of conservation of momentum occurs in the collision of two load beams on a straight track. The speed of two load beams before and after the collision is read on the infrared sensor so that it can be used to calculate the law of conservation of momentum. The law of conservation of momentum occurs in objects that experience perfect collision, partially, or not at all. The total momentum of objects that have collisions before and after the collision will have the same value.

$$p_1 + p_2 = p_1' + p_2'$$

where p_1 and p_2 are the momentum of objects 1 and 2 before collisions, p_1' and p_2' are the momentum of objects 1 and 2 after collision. Momentum is owned by a moving object or speed, which is identified by the level of difficulty in stopping moving objects. Momentum can be expressed as the product of the mass of an object with the speed of motion of the object.

$$p = mv$$

so that the law of conservation of momentum can be expressed in form:

$$p_1 + p_2 = p_1' + p_2'$$

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$$

The first attempt to prove the law of conservation of momentum in partial collision collisions with the mass of the two objects equal to 0.092 kg is presented in Table 2.

The first proof is by launching object 1 without the initial speed in the inclined plane of different heights. Object 1 hits object 2 that stays in a flat plane. The first sensor is placed right at the end of the flat path for data v_1. Sensor 2 is placed right in front of object 2 for data $v_1'$and v_2'. From Table 2 it can be seen that the momentum value of the object before collision approaches the momentum value of the object after collision with a relative error of 1%. This situation can be achieved because the same mass of objects makes it balanced. Another factor is the small friction between objects and track rails.

Table 2. Data for Proof of Momentum Conservation Law with Different Height

h(m)	v_1(m/s)	v_2(m/s)	p_1(kgm/s)	v_1'(m/s)	v_2'(m/s)	p_2(kgm/s)
0.03	0.766812	0	0.070547	0.177	0.589	0.070472
0.04	0.885438	0	0.08146	0.195	0.69	0.081420
0.05	0.989949	0	0.091075	0.222	0.767	0.090988

The second proof is applied to collisions of the same type with a varying second body mass. Speed data by sensors and momentum calculations are presented in Table 3.

Table 3. Data for Proof of Momentum Conservation Law with Different Masses

m_2(kg)	v_1(m/s)	v_2(m/s)	p_1(kgm/s)	v_1'(m/s)	v_2'(m/s)	p_2(kgm/s)
0.117	0.989949	0	0.115824	0.226	0.882	0.108000
0.142	0.989949	0	0.140573	0.231	0.944	0.120000
0.167	0.989949	0	0.165322	0.268	0.997	0.136

Object 1 with a fixed mass of 0.092 kg slides from an inclined plane with a height of 0.05 m pounding a second object. At a mass of 0.117 kg, the difference in momentum before the collision is 0.08 kg.m/s. at a mass of 0.142 kg and 0.167 kg, the difference was 0.021 kgm/s and 0.029 kgm/s respectively. The value of momentum in this second experiment obtained a considerable difference. The state of the second object with a mass greater than the mass of the object 1 that collides causes object 2 to have a greater static friction force. This situation causes objects to be more difficult to move so that the initial velocity of objects when moving is relatively smaller (Halliday et al., 2010).

The results of this trial provide positive values for teachers and students. Saifullah et al. (2017) concluded that students' difficulties in learning can be caused by a lack of understanding of concepts. Through learning that uses practicum media makes what is learned has the benefits of oneself, others, and the community (Azimi et al., 2017). Through a good understanding of concepts, students can represent problem solving well (Lasiani & Aji, 2016).

CONCLUSION

Kit of energy conservation law and momentum practicum was successfully designed. This kit consists of wheeled objects as loads, precision rails as slippery trajectories, and infrared sensor devices to detect the speed of motion of objects before and after collision. The use of this sensor kit provides data on the speed of objects passing through it.

The use of the kit in the energy conservation law practicum and the momentum conservation law was successfully validated and tested. The total constant mechanical energy in moving objects meets the concept of the law of conservation of energy. The value of momentum before the collision approaches the value of momentum after the collision indicates the validity of the momentum conservation law in the designed kit. This study directly proves the law of energy conservation and momentum so that it is in accordance with the prevailing mechanics theory using a simple experimental tool.

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